Claims

1. A method for bonding wafers comprising the steps of :

providing a first wafer having an exposed first layer, the first layer comprising a first metal;

providing a second wafer having an exposed second layer, the second layer comprising a second metal, the first metal and the second metal capable of forming a eutectic mixture having a eutectic melting temperature;

contacting the first layer with the second layer; and

applying a predetermined pressure at a predetermined temperature to form a solid-state diffusion bond between the first layer and the second layer, wherein the predetermined temperature is below the eutectic melting temperature; and

wherein the first metal is not deformable under the predetermined pressure and the second wafer further comprises an irregular surface, the method further comprising the step of :

providing a cushioning layer on the first wafer and adjacent to the first layer, the cushioning layer comprising a soft metal, wherein a melting point of the soft metal is above the predetermined temperature, and the soft metal is deformable under the predetermined pressure to diffuse through the solid-state diffusion bond and trace the contours of the irregular surface of the second wafer.

2. The method of claim 1 wherein the first metal is germanium and the second metal is aluminum.

3. The method of claim 1 wherein the soft metal is copper or aluminum.

4. The method of claim 1 wherein the predetermined temperature is less than 400°C.

5. The method of claim 5 wherein the predetermined temperature is within a range of 250°C and 300°C.

6. The method of claim 1 further comprising the step of performing thermal aging after the formation of the solid-state diffusion bond.

7. The method of claim 1 wherein the predetermined pressure at the predetermined temperature is applied for any one of the following durations: 30 minutes, 60 minutes, 90 minutes and 120 minutes.

8. The method of claim 1 comprising the steps of sputtering the first metal on the first wafer to create the first layer and sputtering the second metal on the second wafer to create the second layer.

9. The method of claim 1 wherein the first metal and the second metal are dissimilar and the first metal and the second metal have substantially similar inter-diffusion coefficients.

10. A wafer comprising :

a first silicon layer and a second silicon layer; and

an intermediary layer between the first silicon layer and the second silicon layer, wherein the intermediary layer comprises a solid-state diffusion bond of a first metal and a second metal; and

wherein the second silicon layer comprises an irregular surface and the wafer further comprises :-

a diffused layer, wherein the diffused layer has diffused through the intermediary layer and comprises a deformable soft metal that traces the contours of the irregular surface of the second silicon layer.

11. The wafer of claim 11 wherein the first metal is germanium and the second metal is aluminum.

12. The wafer of claim 11 wherein the first metal and the second metal are dissimilar and the first metal and the second metal have substantially similar inter-diffusion coefficients.

13. The wafer of claim 11 wherein the soft metal is copper or aluminum.

14. A method for bonding wafers and initiating getter activation, the method comprising the steps of:,

providing a first wafer having an exposed first layer, the first layer comprising a first metal;

providing a second wafer having an exposed second layer, the second layer comprising a second metal, the first metal and the second metal capable of forming a eutectic mixture having a eutectic melting temperature;

contacting the first layer with the second layer; and

applying a predetermined pressure at a predetermined temperature to form a solid-state diffusion bond between the first layer and the second layer, wherein the predetermined temperature is below the eutectic melting temperature

and further comprising the steps of :

providing a first TLP (transient liquid phase) layer on the first wafer;

providing a second TLP layer on the second wafer; and

initiating TLP bonding between the first TLP layer and the second TLP layer to form intermetallic compounds; wherein the predetermined temperature is below a melting temperature of the intermetallic compounds.

15. A method for stacking semiconductor devices comprising the steps of :

fabricating on a surface of a first semiconductor device, connectors comprising a first metal;

applying under-fill to planarize the surface of the first semiconductor device;

fabricating on a surface of a second semiconductor device, connectors comprising a second metal, the first metal and the second metal capable of forming a eutectic mixture having a eutectic melting temperature;

applying under-fill to planarize the surface of the second semiconductor device;

aligning and contacting the connectors on the surface of the first semiconductor device with the connectors on the surface of the second semiconductor device; and

applying a predetermined pressure at a predetermined temperature to form a solid-state diffusion bond between the connectors on the surface of the first semiconductor device and the connectors on the surface of the second semiconductor device, wherein the predetermined temperature is below the eutectic melting temperature; and

wherein the first metal is not deformable under the predetermined pressure and the second semiconductor further comprises an irregular surface, the method further comprising the step of :

providing cushioning layers on the first semiconductor device and each of the cushioning layers is adjacent to each of the connectors of the first semiconductor device, each of the cushioning layers comprising a soft metal, wherein a melting point of the soft metal is above the predetermined temperature, and the soft metal is deformable under the predetermined pressure to diffuse through the solid-state diffusion bond and trace the contours of the irregular surface of the second semiconductor.

16. The method of claim 15 wherein the predetermined pressure is applied using pressurized gas.

17. The method of claim 15 wherein the predetermined temperature is applied by heating the first semiconductor device and the second semiconductor device in an oven to the predetermined temperature.

18. The method of claim 15 wherein the first metal is germanium and the second metal is aluminum.

Listing Of Claims

1. A method for bonding wafers comprising the steps of:

providing a first wafer having an exposed first layer, the first layer comprising a first metal;

providing a second wafer having an exposed second layer, the second layer comprising a second metal, the first metal and the second metal capable of forming a eutectic mixture having a eutectic melting temperature;

contacting the first layer with the second layer; and

applying a predetermined pressure at a predetermined temperature to form a solid-state diffusion bond between the first layer and the second layer, wherein the predetermined temperature is below the eutectic melting temperature; and wherein the first metal is not deformable under the predetermined pressure and the second wafer further comprises an irregular surface, the method further comprising the step of:

providing a cushioning layer on the first wafer and adjacent to the first layer, the cushioning layer comprising a soft metal, wherein a melting point of the soft metal is above the predetermined temperature, and the soft metal is deformable under the predetermined pressure to diffuse through the solid-state diffusion bond and trace the contours of the irregular surface of the second wafer.

2. The method of claim 1 wherein the first metal is germanium and the second metal is aluminum.

3. The method of claim 1 wherein the soft metal is copper or aluminum.

4. The method of claim 1 wherein the predetermined temperature is less than 400°C.

5. The method of claim 4 wherein the predetermined temperature is within a range of 250°C and 300°C.

6. The method of claim 1 further comprising the step of performing thermal aging after the formation of the solid-state diffusion bond.

7. The method of claim 1 wherein the predetermined pressure at the predetermined temperature is applied for any one of the following durations: 30 minutes, 60 minutes, 90 minutes and 120 minutes.

8. The method of claim 1 comprising the steps of sputtering the first metal on the first wafer to create the first layer and sputtering the second metal on the second wafer to create the second layer.

9. The method of claim 1 wherein the first metal and the second metal are dissimilar and the first metal and the second metal have substantially similar inter-diffusion coefficients.

10. A method for bonding wafers and initiating getter activation, the method comprising the steps of:

providing a first wafer having an exposed first layer, the first layer comprising a first metal;

providing a second wafer having an exposed second layer, the second layer comprising a second metal, the first metal and the second metal capable of forming a eutectic mixture having a eutectic melting temperature;

contacting the first layer with the second layer; and

applying a predetermined pressure at a predetermined temperature to form a solid-state diffusion bond between the first layer and the second layer, wherein the predetermined temperature is below the eutectic melting temperature and further comprising the steps of:

providing a first TLP (transient liquid phase) layer on the first wafer;

providing a second TLP layer on the second wafer; and

initiating TLP bonding between the first TLP layer and the second TLP layer to form intermetallic compounds; wherein the predetermined temperature is below a melting temperature of the intermetallic compounds.

11. A method for stacking semiconductor devices comprising the steps of:

fabricating on a surface of a first semiconductor device, connectors comprising a first metal;

applying under-fill to planarize the surface of the first semiconductor device;

fabricating on a surface of a second semiconductor device, connectors comprising a second metal, the first metal and the second metal capable of forming a eutectic mixture having a eutectic melting temperature;

applying under-fill to planarize the surface of the second semiconductor device;

aligning and contacting the connectors on the surface of the first semiconductor device with the connectors on the surface of the second semiconductor device; and

applying a predetermined pressure at a predetermined temperature to form a solid-state diffusion bond between the connectors on the surface of the first semiconductor device and the connectors on the surface of the second semiconductor device, wherein the predetermined temperature is below the eutectic melting temperature; and wherein the first metal is not deformable under the predetermined pressure and the second semiconductor further comprises an irregular surface, the method further comprising the step of :

providing cushioning layers on the first semiconductor device and each of the cushioning layers is adjacent to each of the connectors of the first semiconductor device, each of the cushioning layers comprising a soft metal, wherein a melting point of the soft metal is above the predetermined temperature, and the soft metal is deformable under the predetermined pressure to

diffuse through the solid-state diffusion bond and trace the contours of the irregular surface of the second semiconductor.

12. The method of claim 11 wherein the predetermined pressure is applied using pressurized gas.

13. The method of claim 11 wherein the predetermined temperature is applied by heating the first semiconductor device and the second semiconductor device in an oven to the predetermined temperature.

14. The method of claim 11 wherein the first metal is germanium and the second metal is aluminum.